

First American record of the exotic slug *Tandonia kusceri* (Gastropoda: Milacidae)

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ABSTRACT

The terrestrial slug *Tandonia kusceri* (Pulmonata: Milacidae) is native to the Balkan Peninsula. This article reports the discovery of the species for the first time outside southeastern Europe, in Brookfield, Illinois, USA, a suburb of Chicago. Descriptions and photographs of live animals and reproductive organs are provided to facilitate the recognition of this potential pest species previously unrecorded from the Americas. *Tandonia kusceri* is compared with three other Milacidae species that have been introduced by humans into regions outside their native range, two of which have been recorded from North America. The known distribution and ecology of *T. kusceri* are summarized.

Additional Keywords: Introduced species, genital anatomy

INTRODUCTION

Terrestrial slugs have a long history of being introduced to the Americas from other continents. At least 26 species have been reported as having established populations in the USA and Canada (Turgeon et al., 1998; Reise et al., 2000, 2006; Grimm et al., 2009). Introduced slug species can pose threats to the environment, e.g., by competing with native species (Rollo, 1983), and they can become important agricultural pests (Mc Donnell et al., 2009 and references therein). Consequently, considerable amounts of manpower and money are spent by governments (e.g., U.S. Department of Agriculture [USDA]) to prevent additional species from entering North America, to limit the spread, and, if possible, eradicate limited occurrences of newly introduced species. Nevertheless, ever-increasing international trade has the unfortunate side effect that additional alien slug species (along with other mollusks and other animals and plants) continue to be introduced to America (Robinson, 1999; Robinson and Slapcinsky, 2005). Efforts to prevent new introductions and to limit the spread of alien species, as well as attempts to discover the avenues of their

introduction, are more likely to be successful if introduced species are documented as early as possible (Reise et al., 2000; 2006; Robinson and Slapcinsky, 2005).

In this article, the first American record of the alien slug *Tandonia kusceri* (H. Wagner, 1931) is reported. Photographs and descriptions of the animal and its genital anatomy are provided as identification tools.

MATERIALS AND METHODS

Voucher material has been deposited in the Mollusk Collection of the Field Museum of Natural History, Chicago (FMNH) and the USDA National Mollusk Collection, Philadelphia (USDA):

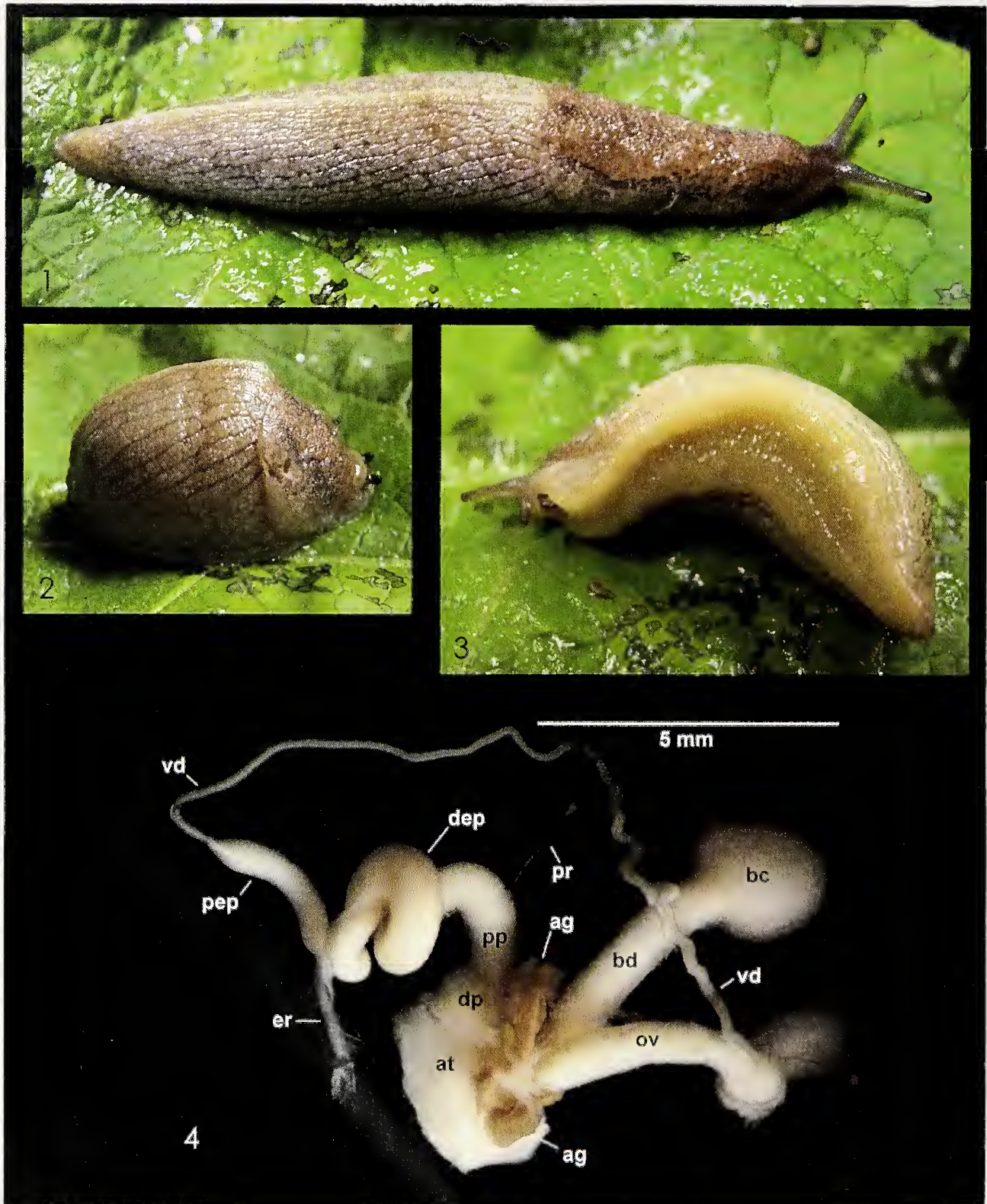
USA, Illinois, Cook County, Brookfield, near the intersection of Jefferson and Harrison Avenues, 41°49'42" N, 87°51'23" W, 190 m a.s.l., crawling on concrete porch after rain, at about 23:00h, 21 June 2013, leg. M.K. Thayer (FMNH 328572: 8 specimens preserved in 70% ethanol + tissue samples of 5 of these specimens in 95% ethanol; USDA 140056: 2 specimens preserved in 70% ethanol).

Same locality, but found in front yard, buried 10 cm deep in garden soil; 5 October 2013, leg. M.K. Thayer (FMNH 328573: 1 specimen in 70% ethanol; FMNH 328574: 1 dried specimen [mummified after escape from container in which specimens were kept]).

IDENTIFICATION

The descriptions (Figures 1–4) given here are based on the Brookfield specimens of *T. kusceri*.

External Morphology: Fully extended, mature specimens ca. 7 cm long, rather slender. Length of mantle shield in the front half of the body about 1/3 total body length. Breathing pore at about 3/4 of the mantle length from the anterior mantle margin, on the right side of the mantle shield. Mantle shield with a horseshoe-shaped groove open posteriorly. Surface of mantle shield granular. A keel extends along the middle of the dorsum,



Figures 1–4. *Tandonia kusceri* from Bolingbrook, Illinois, USA (FMNH 328572). 1. Extended specimen, length about 6.5 cm. 2. Contracted specimen. 3. Animal with sole exposed. 4. Distal portion of the reproductive tract. Abbreviations: **ag**, accessory gland; **at**, genital atrium; **bc**, bursa copulatrix; **bd**, duct of bursa copulatrix; **dep**, distal part of epiphallus; **dp**, distal part of penis; **er**, epiphallus retractor; **ov**, oviduct; **pep**, proximal part of epiphallus; **pp**, proximal part of penis; **pr**, penis retractor; **vd**, vas deferens.

from the tail end to the posterior edge of the mantle shield. Back and sides with about 15 diagonal rows of flattened tubercles on each side. When resting, specimens can contract strongly antero-posteriorly, so as to attain nearly a half-circle shape when seen from the side.

Overall color light yellowish- to pinkish-brown, becoming lighter toward the sole. Black pigment concentrated in the furrows separating the skin tubercles, which results in a reticulated pattern. Keel lighter-colored than back, without black pigment. Mantle diffusely speckled with dark pigment. A dark band present on either side along the branches of the horseshoe groove. Another, somewhat less distinct longitudinal pigment band in the center of the mantle shield. Head and tentacles brownish-grey. Sole tripartite, uniformly pale yellowish, without dark pigment. Mucus of body and sole colorless, transparent, slightly milky when animal irritated.

Genitalia: Ootestis in the dissected specimens ($n=2$) large, suggesting sexual maturity. Hermaphroditic duct long and thin. Albumen gland large (again, suggesting sexual maturity), elongated and bent. Spermoviduct wide and twisted. Vas deferens thin and almost 1.5 times as long as penis and epiphallus combined, opening apically into the conically attenuated proximal end of the epiphallus. Epiphallus tubular, wider distally than proximally, very long, about five times as long as the penis, intensely coiled and twisted. A broad retractor muscle inserting on the epiphallus about $\frac{1}{4}$ of its length from its proximal end. Boundary between epiphallus and penis marked by the insertion of a thin second retractor muscle. Penis with two distinct sections: a tubular proximal part about as wide as the distal epiphallus or hardly wider, and a distal part that is short and globular, about twice as wide as the proximal part.

Oviduct tubular, straight or but lightly bent. Bursa copulatrix large, spherical. Bursa duct thick, its diameter slightly more than $\frac{1}{3}$ of the bursa diameter, and about twice as long as the bursa.

Accessory glands are two crinkled lobes, one roundish, the other elongated, that are attached to the vagina at the transition to the oviduct and bursa duct. The glands are of a beige color (as opposed to the white surrounding reproductive organs). Vagina and atrium short.

Epiphallus and bursa copulatrix with its duct were examined for the presence of a spermatophore but none was observed.

Distribution: The native distribution area of *T. kusceri* lies in the Balkans. It stretches from Central Serbia through FYR Macedonia, northeastern Greece, and Bulgaria to European Turkey and Southeast Romania (Dedov and Mitev, 2011; Reischütz, 1988; Wiktor, 1987; 2001). Occurrences of the species in Croatia, coastal Southwest Ukraine, and Crimea are presumed to be the result of human introductions (Son, 2010; Sysoev and Schileyko, 2009; Wiktor, 1987; 1996).

Ecology: According to Wiktor (1987), *T. kusceri* is a "species of very high ecological tolerance, occurring in biotopes of various humidity, most often found in places of large quantity of loose stones, under which it shelters. Occurring in shrubs, woods, stone debris, and synanthropically. Usually in large numbers, especially on limestone, and in biotopes heavily destroyed by man (wasteland, dumps, ruins)." Recorded elevations range from sea level (e.g., Varna, Bulgaria and Odessa, Ukraine; Wiktor, 1983; 1987; Son, 2010) to 1450 m a.s.l. (Osogovo Mountains, FYR Macedonia; Dedov and Mitev, 2011). Welter-Schultes (2012) states that *T. kusceri* occurs "in Bulgaria in up to 2000 m." However, none of the references he gives contains such an elevation record and it is unclear on what this statement is based.

According to observations at the Bolingbrook site, *T. kusceri* is only active at night. On 5 October 2013 two specimens were discovered during the day, buried 10 cm deep in garden soil. One of the specimens collected in October 2013 was held captive until late March 2014. The specimen was strictly nocturnal in its habits. During the day it stayed buried in the soil covering the bottom of the container rather than using items like pieces of tree bark that were offered for shelter.

DISCUSSION

Several species in the Milacidae, namely *Milax gagates* (Draparnaud, 1801), *Tandonia budapestensis* (Hazay, 1881) and *Tandonia sowerbyi* (A. Férussac, 1823), are known as invasives in areas far beyond their native southern European range. *Milax gagates* has been introduced around the world including North and South America (Wiktor, 1987; Turgeon et al., 1998; Grimm et al., 2009; McDonnell et al., 2009) and *T. budapestensis* has been recorded in the eastern United States (Reise et al., 2006). Consequently, it seemed likely that the milacids from Brookfield belonged to one of these tramp species. However, the attempt to assign the specimens to one of these species based on external characters failed. Dissections clearly showed that the Brookfield specimens were not conspecific with any of these invasives, but that they instead belonged to *Tandonia kusceri*, a species that had not been found previously outside of south-eastern Europe.

The combination of an extremely long vas deferens and epiphallus, the latter being intensely coiled and twisted, a short, bipartite penis, and a large, bulbous bursa with a thick tubular duct is unique among the Milacidae and allows for easy recognition of *T. kusceri*. Figure 4 shows the distal parts of the reproductive tract of a specimen from Bolingbrook (FMNH 328572). It resembles Wiktor's (1987: 258–259, fig. 155) description and drawing of the genital anatomy of *T. kusceri* very closely. The only differences are: Wiktor shows a constriction at the insertion of the penis retractor, i.e., at the epiphallus-penis boundary. No such constriction is discernible in the Bolingbrook specimen. Secondly, the

broad retractor inserting on the epiphallus about $\frac{1}{4}$ of its length from its proximal end is neither mentioned nor figured by Wiktor. However this feature is depicted in two of the drawings of the genitalia of *T. kusceri* (as *Milax [M.] kusceri*) by Grossu (1983: 223, fig. 139; 124, fig. 140).

Externally, the Bolingbrook specimens agree with the description of *T. kusceri* given by Wiktor (1987). Wiktor states that extended specimens are up to 10 cm long. The specimen figured by him (1987: 258, fig. 154) measures about 6.5 cm.

Other milacid species recorded from North America differ as follows (Wiktor, 1987):

Milax gagates – Vas deferens short; epiphallus club-shaped, proximally truncated, short; penis irregularly rounded, short, almost half the length of the epiphallus; bursa copulatrix elongated, its duct very short and indistinct; accessory glands open into the atrium (not the vagina) through numerous tubules (characteristic for genus *Milax*); atrial stimulator present (characteristic for genus *Milax*). Body tends to be uniformly dark grey or blackish, without pigment spots.

Tandonia budapestensis – Vas deferens short; epiphallus short, as long as or slightly longer than penis, cylindrical or club-shaped; penis irregularly rounded; bursa copulatrix oval to cylindrical, its duct thick and short. Body appearing variably blackish-brown due to dense black spotting on a dull cream or orange background; keel olive or orange, without black pigment. When resting, animals often curl into a c-shape, as opposed to other milacids which contract into a “hump” (Kerney and Cameron, 1979; Reise et al., 2006).

Tandonia sowerbyi has been introduced into large parts of southern and western Europe as well as South America and New Zealand, but has not been recorded from North America. It can be similar to *T. kusceri* in its external appearance (Wiktor, 2001) but differs clearly in its genital anatomy (Wiktor, 1987; 2001): Vas deferens long, narrow, twisted, about three times as long as the epiphallus (Wiktor, 1987: 301 states “twice as long” but fig. 215 on p. 302 shows the vas deferens to be clearly at least three times as long as the epiphallus); epiphallus a thick cylinder tapering and slightly bending toward the vas deferens; a strong retractor muscle inserting laterally on the epiphallus about $\frac{2}{3}$ of its length from its proximal end; two additional muscles, interpreted as retentors, inserting laterally (pointing away from each other) near the distal end of the epiphallus, close to a constriction marking the epiphallus-penis boundary; penis more or less cylindrical, about as wide as epiphallus, its length less than half to ca. $\frac{3}{4}$ of the epiphallus length; bursa copulatrix strongly elongated, tubular in younger specimens, distally wider and clearly delimited from duct in older specimens; bursa duct narrower and shorter than bursa.

At this point it is not clear if the *T. kusceri* population in Brookfield is the result of a recent introduction and restricted to the immediate area around the collection site, or if the species has been there for a number of years and occupies a wider area. We do not know how this exotic species was introduced. The fact that the discoverer, Dr. Margaret K. Thayer, who has lived at this address for the last 25 years and who, as an experienced zoologist, is trained to take notice of unusual animal occurrences, does not remember seeing this slug in previous years seems to point to a recent arrival on the Thayer property. However, it is currently impossible to state with certainty whether the slugs have recently migrated from nearby yards and gardens where they may have dwelled for some time and how and when they arrived there. I intend to monitor the *Tandonia* population in Bolingbrook and learn more about the extent of the infestation in the coming months.

The apparently very wide ecological amplitude of *T. kusceri* and its synanthropic tendencies (Wiktor, 1987) suggest that the species could be successful in becoming established in North America.

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